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The Role of logmat Biofilm in the Spirit Lake Ecosystem after the Eruption of Mt. St. Helens

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The role of log mat biofilm in the Spirit Lake ecosystem after the eruption of Mount St. Helens

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PHYSICAL SETTING

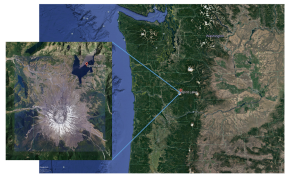
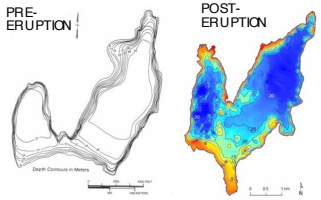


Figure 1. Location of Spirit Lake on the **NE edge of Mt. St. Helens**, Skamania County Washington

Figure 2. Eruption of Mt. St. Helens May 10, 1980, triggering collapse of northern flank



A lake in the blast zone: an environment molded by an active volcano. Debris flow of volcanic material sterilized the lake of all organic content and dramatically changed lake morphology.

Figure 3. Bathymetric map of Spirit lake pre and post eruption depicting changes to lake morphology. The lake became shallower and smaller as a result of the deposition of landslide debris (Gawel et. al 2018).

Figure 4. Flattened or blown-down trees from the eruption

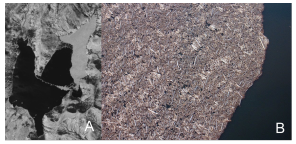
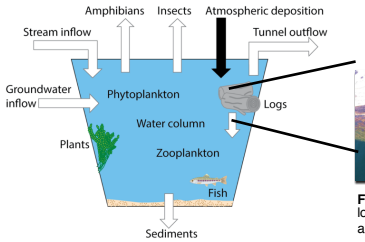


Figure 5. A. Floating log mat which covers 20% of lakes surface area. **B.** Close-up of logs

Trees flattened by the volcanic landslide washed into the lake as a floating log mat now covering 20% of the lake surface area.

BIOGEOCHEMICAL SETTING

Spirit lake is an oligotrophic lake.
Floating log mats provide a substrate for biofilm primary productivity.



***Biofilm** is primarily comprised of algae, cyanobacteria, & diatoms*

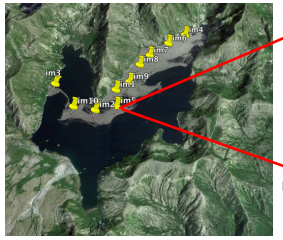
Figure 7. Underside of submerged log, provides substrate for biofilm accumulation.

Figure 6. Nutrient Budget for Spirit Lake. Notable primary producers include macrophytes, phytoplankton, and biofilm. The role of log mat derived biofilm has not been fully resolved (Gawel et. al 2018).

MOTIVATING QUESTIONS

- **What is the biomass of log mat biofilm in Spirit Lake?**
- **How variable is the lake sediment record across space and through time?**

BIOFILM BIOMASS ESTIMATES



Estimated biofilm surface area: 2.5 km^2

(total lake surface area: 11 km^2)

Figure 8. Satellite imagery from Google Earth used in biofilm surface area estimate. Experimental test plot (100 m^2 showing log mat density)

Log mat biofilm surface area estimate for Spirit Lake

* Sampled 10 different locations, analyzed logs within 100m^2 area
* Binned logs into three size classes
* Calculated 3D area of semi-cylinder for logs in each size class
* Calculated average submerged surface area per 100m^2 of log mat
* Extrapolated to total log mat area using Google Earth

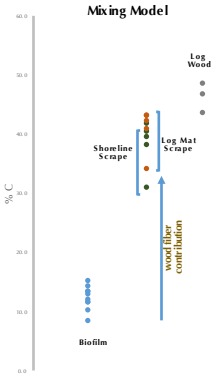


Figure 9. Mixing model for log biofilm scrapes. End members are "pure" biofilm (%C = 12.1%) and log wood (%C = 46.0%).

Log mat biofilm BIOMASS estimate for Spirit Lake

*Sampling of log biofilm using razor scrape from 10 log mat and shoreline logs
*Mixing model using %C values for biofilm and log wood to account for wood biomass in scrape samples
* %C data confirm variable amounts of wood fibers in biofilm samples
*Shoreline logs contain greater biofilm occupation than experimental log mat logs, likely as a result of cumulative biofilm accumulation.
*Experimental log mat logs only represent 3 months of accumulation.
***Total Biofilm Biomass** estimated to be **12,646 kg** with a standard deviation of **9873 kg**

BIOFILM CONTRIBUTION TO LAKE SEDIMENTS

Lake sediments Integrate and record lake organics

*Shallow sediment samples reflect variable organic inputs depending on location in lake
*Sediments with highest organic content are found in areas of the lake with most frequent log mat occupancy during summer months

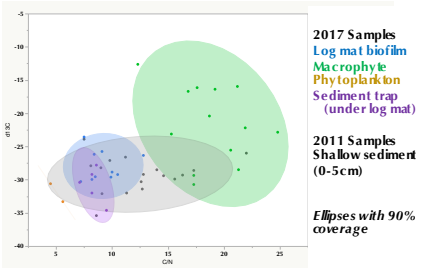
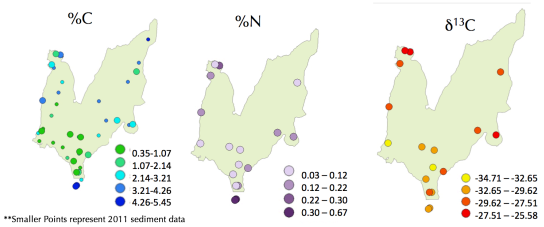


Figure 10. Bivariate plot comparing 2017 biofilm, macrophyte, phytoplankton and sediment samples. Biofilm $\delta^{13}C$ values and C/N ratios are distinct from other primary producers. Sediment traps under log mats link biofilm to suspended organic material. (Fox-Dobbs, unpub. data)

SPATIAL VARIABILITY IN LAKE SEDIMENTS



**Smaller Points represent 2011 sediment data

Figure 11. Map of Spirit Lake depicting % C, % N and, $\delta^{13}C$ values of shallow sediments. Greatest %C (organic content) in samples from the NW arm where floating log mat primarily occupies. $\delta^{13}C$ values in Duck Bay indicate potential methanogenesis in sediments.

Organic C and N content

*25 sediment dredge samples collected in 2011
*17 sediment dredge samples collected in 2018
*Generally higher organic C and N in regions where floating log mat primarily occupies
*Low $\delta^{13}C$ values in Duck Bay related to methanogenesis

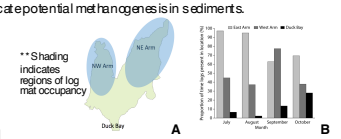


Figure 12. A. Map of Spirit Lake depicting primary regions of the lake. **B.** Bar Graphs showing log mat occupancy for summer months. Log mat primarily occupies NW and NE Arm, though occupancy shifts based on prevailing wind patterns (Gawel, et al. 2018)

CHANGES IN LAKE SEDIMENT THROUGH TIME

An ecosystem reaching equilibrium?

*Comparison between 2010 (22 cm) and 2018 (18 cm) Duck Bay Cores collected using a gravity corer
*Provides sedimentation rate over the past 8 years
*Changes in organic C and N flux over time, including rapid transitions from a sterile to eutrophic to oligotrophic system
*Consistent %C and %N over the past 8 years may represent recent equilibrium in the lake ecosystem
*Varves (dark banding) correlated with higher %C values

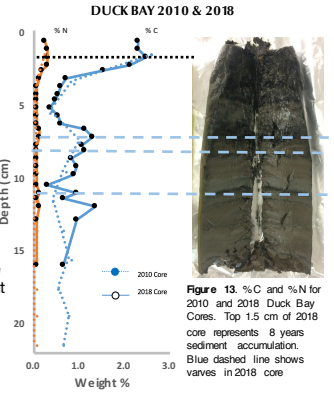
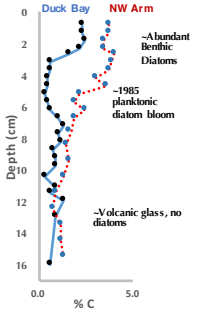


Figure 13. %C and %N for 2010 and 2018 Duck Bay Cores. Top 1.5 cm of 2018 core represents 8 years sediment accumulation. Blue dashed line shows varves in 2018 core



A Story of Two Cores

- Comparison between 2018 **Duck Bay Core** (18 cm) and 2018 **NW Arm Core** (18 cm)
- For much of the core record NW Arm has higher %C than Duck Bay, suggesting that log mat occupancy = organic supply
- Both cores show %C peak around 6 cm depth, tied to **planktonic diatom bloom**
- Low %C in deep core samples due to post-eruption early lake ecosystem evolution

Figure 14. %C for Duck Bay (Blue) and NW Arm Core (Red). Cores in two different regions of the lake show different patterns with depth. Annotated with important events in lake history.

ACKNOWLEDGMENTS

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